GEOLOGY

Geology of the

QUEEN OF SHEBA LEAD MINE

Death Valley, California

SPECIAL REPORT 88

California Division of Mines and Geology
Ferry Building, San Francisco

1965

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PAUL K. MORTON, Geologist
lifornia Division of Mines and Geology

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CALIFORNIA DIVISION OF MINES AND GEOLOGY
FERRY BUILDING, SAN FRANCISCO, 1965

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ABSTRACT

The Queen of Sheba mine is in the southern part of Inyo County at the eastern base of the southern Panamint Range about 37 miles west of Shoshone and 32 miles south of Furnace Creek Ranch. From its discovery in 1913 through 1962, the mine yielded about 16,000 tons of crude ore that averaged 15.5 percent lead, 0.5 percent copper, 6.3 ounces of silver, and 0.09 ounce of gold per ton.

The mine area is underlain by diabase and quartzite of the later Precambrian Crystal Spring Formation and Lower Cambrian(?) Noonday Dolomite. Northeast-striking normal faults divide these rocks into three structural blocks, two of which contain ore bodies. The Queen of Sheba ore body consists of irregular replacement by galena in favorable strata of Noonday Dolomite, which strike N.50°W. and dip 25°NE. Thirteen hundred feet to the northeast is the Carbonate ore body, the more productive of the two. It is a disordered mass of brecciated and highly oxidized ore that lies within an apparently landslid mass of Noonday Dolomite. The Carbonate ore body strikes roughly north and dips about 40 degrees eastward. Cerussite is the most abundant ore mineral.

The two ore bodies may have been originally in vertical or horizontal juxtaposition and became separated as a result of faulting and landsliding. Similar deposits may exist in adjacent areas.

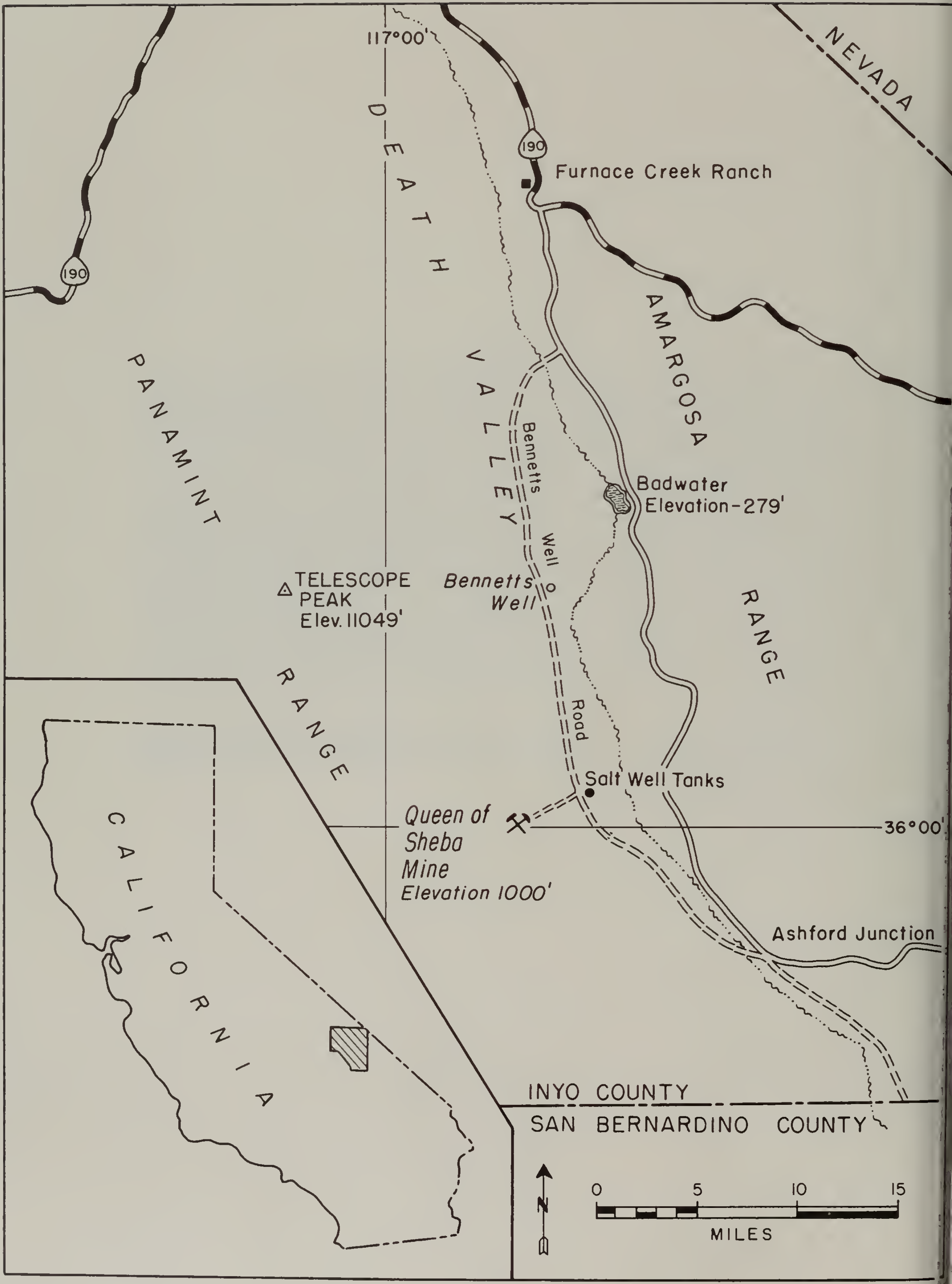


Figure 1. Index map showing location of Queen of Sheba mine.

OLOGY OF THE QUEEN OF SHEBA LEAD MINE
ATH VALLEY, CALIFORNIA

PAUL K. MORTON, Geologist
ifornia Division of Mines and Geology

INTRODUCTION

on and Accessibility

he Queen of Sheba mine is in southern Inyo County ut 37 miles west of Shoshone and 32 miles south of nace Creek Ranch. It lies within Death Valley Na- al Monument in the NE¼ of sec. 20, T.22N., R.1E., M. along the eastern base of the Panamint Range. mine is accessible by car via the Bennetts Well road he west side of Death Valley to Salt Well Tanks. n there a secondary road extends 4 miles westward e mine (fig. 1).

e mine workings lie at elevations between 800 feet l,400 feet, at the northeast tip of a northeast-trending of the range. The spur is split at its lower end by all valley that separates the two groups of mine ings.

e and Water

e climate is extremely arid, with a mean annual rain- f about 4 inches (Dale, 1959, p. 34). Daytime tem- ures regularly exceed 100° F. from June through mber, but are moderate most of the remainder of ear. Cold, strong windy periods are common during of the winter.

e nearest sources of fresh water are at a spring in a Canyon, 2 miles northwest of the mine, and at n Spring, 3½ miles southwest of the mine. The s are 9 and 12 miles, respectively, via secondary from the mine. Neither spring is known to have ed water for use at the Queen of Sheba mine. Most water used at the mine was hauled from Zabriskie, on on the now abandoned Tonopah and Tidewater ay. Saline water from Salt Well, 4 miles northeast mine was utilized in a mill operated at the mine w Sutherland Divide Mining Co. in 1948–49. The was pumped 4 miles in 2 stages against a 1,200-foot

nd Production

Queen of Sheba mine, originally known as the nate mine, was discovered in 1913. Mining was in 1915 by the Carbonate Lead Mines Co., which was superseded by the New Sutherland Divide Mining Co. about 1920. During the first 3 years of operation, 11,000 tons of ore was mined. This contained about 15 percent lead and 5 ounces of silver per ton. The ore was hauled 45 miles in tractor-drawn trucks to Zabriskie (Waring and Huguenin, 1919, p. 90). The trucks hauled water to the mine on the return trip. From Zabriskie the ore was shipped by rail to the U.S. Smelting and Refining Co. smelter at Midvale, Utah.

Since 1917, the mine has been operated intermittently by several lessees and production has been rather spas- modic. From 1917 through 1925, about 200 tons of crude ore was mined. During 1930–31, as much as 3,400 tons of ore was mined, and during the years 1932–35 less than 1,000 tons was mined. The mine lay idle until 1948–49 when several hundred tons of ore was mined and milled by the New Sutherland Divide Mining Co. This com- pany relinquished its interest in the property in 1950 to Mr. Wm. Friml, of Hollywood, the present owner. Goldfield Consolidated Mining Co. leased the property during 1952–1953, and drilled an area a few hundred feet southwest of the Queen of Sheba workings. The drilling failed to indicate the presence of new ore bodies. In 1961, the property was under lease to Mr. Ray Bennett of Westminster, California.

The Queen of Sheba mine has yielded a total of 16,000 tons of crude ore from which were extracted about 5,000,000 pounds of lead, 100,000 ounces of silver, 1,500 ounces of gold and 146,000 pounds of copper. The ore has averaged 15.5 percent lead and 0.5 percent copper, and 6.3 ounces of silver and .09 ounces of gold per ton.

Previous Work and Acknowledgments

Brief descriptions of the Queen of Sheba mine have been written by Waring and Huguenin (1919, p. 89–90), Newman (1923, p. 30), Tucker (1924, p. 33; 1926, p. 480; 1938, p. 430–431, 470), Eric (1948, p. 239), and Norman and Stewart (1951, p. 76). An unpublished re- port was prepared in 1953 by H. N. Witt of Goldfield Consolidated Mining Co. The general geology of the area including the mine is shown on a geologic map assembled by Noble and Wright (1954) and on the Death Valley sheet of the Geologic Map of California (Jennings, 1958).

This study of the Queen of Sheba mine area was begun in October 1959 and completed in July 1960. Thirty days were spent in the field making topographic and geologic maps of the surface, and geologic maps of the underground workings. A map was made by plane table at a scale of 1 inch to 200 feet and enlarged to 1 inch to 100 feet before mapping the geology. Underground maps were surveyed by Brunton Compass and tape at a scale of 1 inch to 20 feet.

The writer wishes to acknowledge the helpful criticisms and assistance in plane tabling by L. A. Wright and B. W. Troxel, and the cooperation given by H. N. Witt of Goldfield Consolidated Mining Company. W. L. Knight, R. A. Matthews, and G. W. Putman of the California Division of Mines and Geology assisted the writer in identification of some of the minerals. Drafting of the plates and figures was artistically performed by Dorismae Weber of the Division's drafting section.

DESCRIPTION OF WORKINGS

The Queen of Sheba mine consists of two distinct deposits and two corresponding groups of workings—the Carbonate deposit and workings, and the Queen of Sheba deposit and workings. The Carbonate workings occupy the lower part of a long, narrow ridge in the northeast part of the mapped area. There, three principal adits provide access to about 1600 feet of horizontal workings on four levels. The Queen of Sheba workings are in a higher, flat-topped ridge about 1300 feet southwest of the Carbonate workings. Four adits driven southwestward into the ridge on four levels provide access to about 1900 feet of level workings.

The productive levels in the Carbonate deposit consist of two drift-adits driven at elevations of approximately 975 and 965 feet. Both levels are now partly caved, but fragmentary evidence suggests that each consisted of from 100 to 150 feet of drift. Two lower levels are far more extensive but were much less productive. The upper of these (904 level) is a tunnel driven through the ridge to explore underneath the ore bodies mined from the levels above. It is connected to those upper workings by raises and to the level below (816 level) by a raise. The 816 level was driven about 400 feet S.75°W., also to explore the downward projection of upper-level ore bodies; it proved unproductive.

The four adits at the Queen of Sheba workings are known as the Lower Crosscut (approximate elevation 1157 feet), and Crosscuts No. 1, 2, and 3 (approximate elevations 1272, 1304, and 1321 feet, respectively). Crosscut No. 3, the highest level, was driven 100 feet southwest; a 50-foot drift, appended to the crosscut, was driven southeast from a point near the portal. Ore has
stoped 20 feet to the surface from the drift. Cr
No. 2 was driven 120 feet southwest, with drifts a
gating about 200 feet appended at erratic interval
plate 3). Crosscut No. 1, an unproductive level
driven 90 feet southwest and connects with abou
feet of additional exploratory workings. The L
Crosscut was driven 300 feet S.40°W. and thenc
feet almost due west. From a point 550 feet fro
portal, exploratory workings totaling about 500 feet
driven generally southeast. An additional 180 fe
workings were driven to the northwest from a
about 265 feet from the portal.

GEOLOGY OF THE MINE AREA

General Features

The east face of the Panamint Range, in area
rounding the Queen of Sheba mine, is underlain r
by dolomite, quartzite, and diabase of the later Pr
brian Crystal Spring Formation and by Cambria
marine Noonday Dolomite. The Crystal Spring F
tion rests unconformably upon early Precambrian
and gneiss, which are exposed one mile southwest
mine area in Silver Lady Canyon, and is, in turn,
lain unconformably by Noonday Dolomite. Precar
and Paleozoic rocks of the region are intruded by
zoic (?) granitic rocks, the two nearest exposu
which are about 12 miles northwest of the mine,
Warm Spring Canyon, 4 miles southwest of the
The Crystal Spring Formation and Noonday Do
are overlain by Tertiary volcanic rocks a few miles
of the mine area and by Cambrian and younger
zoic marine strata north of the mine area. A ro
just a few hundred feet south of the mapped area e
a very small flat-lying body of gray-white vitr
which lies unconformably on Noonday Dolomite
tuff is undeformed, and may be Quaternary in ag

On the west-trending ridges and canyons adjac
the Queen of Sheba mine the Crystal Spring For
and Noonday Dolomite predominate. Pale-colored
day Dolomite lies with apparent unconformity up
darker brownish-colored Crystal Spring Formatic
the contact is commonly obscured by talus or by
brecciation due to landsliding or faulting.

The east side of the southern part of the Pa
Range is broadly homoclinal in structure; Preca
and Cambrian rocks dip northeastward at m
angles and Tertiary volcanic rocks dip northea
at more gentle angles. Numerous northwest-t
faults offset the strata.

Crystal Spring Formation (Later Precambrian)

Quartzite. Quartzite of the Crystal Spring Fo
crops out in the mapped area as two very sma

thinly bedded pinkish-gray quartzite in a sill-like body diabase (pl. 1). One septum crops out about 500 feet e north of the main Carbonate workings adjacent to gully on the northern border of the mapped area. The ond and larger exposure is about 600 feet southwest the main Carbonate workings on the opposite side of ridge south of the smaller exposure. The beds in the ger exposure strike about N.15°W. and dip 70°NE., l those in the smaller strike about N.30°E. and dip SE. Bedding, however, in both localities appears to slightly contorted.

he quartzite weathers to a brownish-black color that nds indiscernibly into the blackish color of the sur- nding diabase. Fresh quartzite shows thin alterating vish pink and black layers which range in thickness n a fraction of a millimeter to a centimeter or more. nly one thin section of the quartzite was examined. composed chiefly of very fine-grained, equigranular, rlocking grains of quartz with abundant magnetite ns in the dark layers. Scattered grains of apatite, and or amounts of sericite and chlorite are also present.

iabase. The diabase crops out in the western part e mine area. Its blackish color contrasts sharply with lighter hue of the overlying Noonday Dolomite, ting a patchwork-like pattern when viewed from a nce.

e diabase is closely jointed, and areas underlain by e commonly mantled with abundant loose cobble- fragments. It forms slightly rounded, subdued graphy which is in sharp contrast to the craggy res of Noonday Dolomite.

e fresh diabase is greenish-black, and medium ed. Two thin sections of representative specimens found to be composed of about 60 percent andesine s), 20 percent augite, 10 percent sericite, and 10 nt magnetite. Chlorite after augite, and small scat- blebs of quartz are present in minor amounts.

ause no undisturbed upper or lower contacts of iabase are exposed in the mine area the thickness diabase cannot be estimated; elsewhere in south- eath Valley the diabase forms sill-like bodies as as 600 feet thick (Wright, 1952, p. 14).

Noonday Dolomite (Lower Cambrian(?))

Noonday Dolomite in the mine area consists of per thinly bedded member and a lower massive er. These correspond to the generally recognized and lower members of the Noonday Dolomite cribed by Johnson (1957). Together they are at 00 feet thick.

dolomite crops out in the mine area in three t masses. The smallest mass, which is highly brec- te underlies the narrow east-trending ridge that con- he Carbonate ore body in the north part of the area. The largest mass underlies the large flat-topped ridge containing the Queen of Sheba ore body in the southern part of the area. It is, for the most part, unbrecciated. A third mass lies along the western boundary of the mapped area and extends westward beyond it. This mass is brecciated along its lower contact.

Outside the mapped area, the Noonday Dolomite lies unconformably on rocks of the later Precambrian Crystal Spring Formation. Within the mapped area, the lower contact of the largest mass of Noonday Dolomite is not exposed, and the smaller masses are severely brecciated along the lower contacts.

Natural exposures of Noonday Dolomite are grayish-buff, massive, and very resistant to erosion with extremely rugged topographic expression. The dolomite very commonly forms resistant caps on ridges, and even the talus and slope wash from the dolomite form a tenacious cover over other rocks.

The lower unit of dolomite is a massive, tough, dense, resistant rock which is very fine grained. On fresh surfaces it is creamy gray, but on weathered surfaces it is light grayish-buff in color. The beds are 3 to 6 feet thick but commonly are indistinct. The unit weathers into large bouldery rubble which becomes recemented and clings to the hillsides in apron-like fashion. It contains sparse and irregularly dispersed vugs about a quarter of an inch in diameter, which generally contain medium-grained crystals of secondary calcite or, less commonly, fine-grained quartz. It also contains subordinate and discontinuous thin layers of sandy dolomite ranging in thickness from $\frac{1}{16}$ to ¼ inch or more. The surfaces of these layers are commonly stained to resistant black manganiferous bands by weathering. Scattered, tiny grains of quartz are present also in most of the remaining dolomite, causing weathered material to form rough, abrasive surfaces which cling to the skin when touched.

The massive lower unit of the Noonday Dolomite commonly contains peculiar, irregularly shaped quartz-filled "tubes" of undetermined origin (fig. 2). They range in diameter from ¼ inch to 1 inch and are as much as 2 feet or more in length. They are spaced at irregular intervals, but commonly are from 3 to 12 inches apart. Tubes less than 3 inches apart are commonly interlaced by quartz along bedding planes and less commonly in a weblike fashion. Wherever bedding can be observed, the tubes are perpendicular to the bedding. In fact, the orientation is consistent enough to warrant determining dip and strike of bedding from them where bedding is obscure. This perpendicularity suggests that these features originated while the beds were horizontal. The distribution of the tubes is erratic, and in the mine area apparently is not typical of any particular position within the massive unit. The tubes have been noted by other workers to be characteristic of the lowest of the recog-

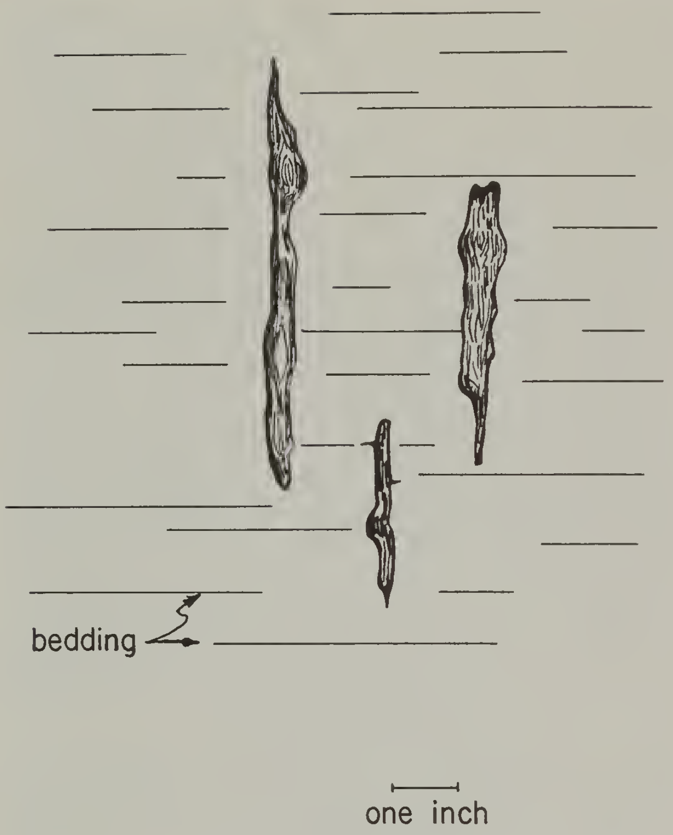


Figure 2. Sketch of quartz-filled "tubes" in Noonday dolomite.

nized members of the Noonday Dolomite in the Death Valley region.

Some of these tubes that occur near ore zones are replaced in part by galena.

The upper unit of the Noonday Dolomite in the mapped area is exposed only in a small area northeast of the Queen of Sheba workings. It consists of about 50 feet of very thinly bedded, pale, creamy gray, poorly resistant, fine-grained, limy dolomite. The beds are mildly contorted, but in general they strike about N.40°W. and dip 30 to 60° NE. To the southeast and northwest this unit is obscured by thick accumulations of talus and alluvium. The contact between it and the underlying massive dolomite appears to be a bedding-plane fault. One thin section of the rock was examined, which was composed of very fine-grained dolomite and calcite with scattered tiny grains of quartz and minor flakes of sericite and grains of hydrous iron oxides.

Quaternary Alluvium

Quaternary alluvium of two ages flanks the base of the steep ridge in the southeast part of the mapped area, and underlies the low spur that extends north from the ridge. The older unit is a loosely consolidated, dissected fanglomerate derived largely from Silver Lady Canyon, an adjacent canyon to the south. It is made up of subangular to well-rounded, poorly sorted fragments,
cluding a large proportion of earlier Precambrian sc

The more recent alluvium and talus covers muc
the low area between the Queen of Sheba workings
the Carbonate workings. The alluvium is compose
locally derived cobble-sized angular fragments of N
day Dolomite, diabase, and minor quartzite in a ma
of sandy clay. The talus, which is as much as 20
thick, mantles most of the lower margins of the rid
and obscures much of the bedrock near the portal
principal workings.

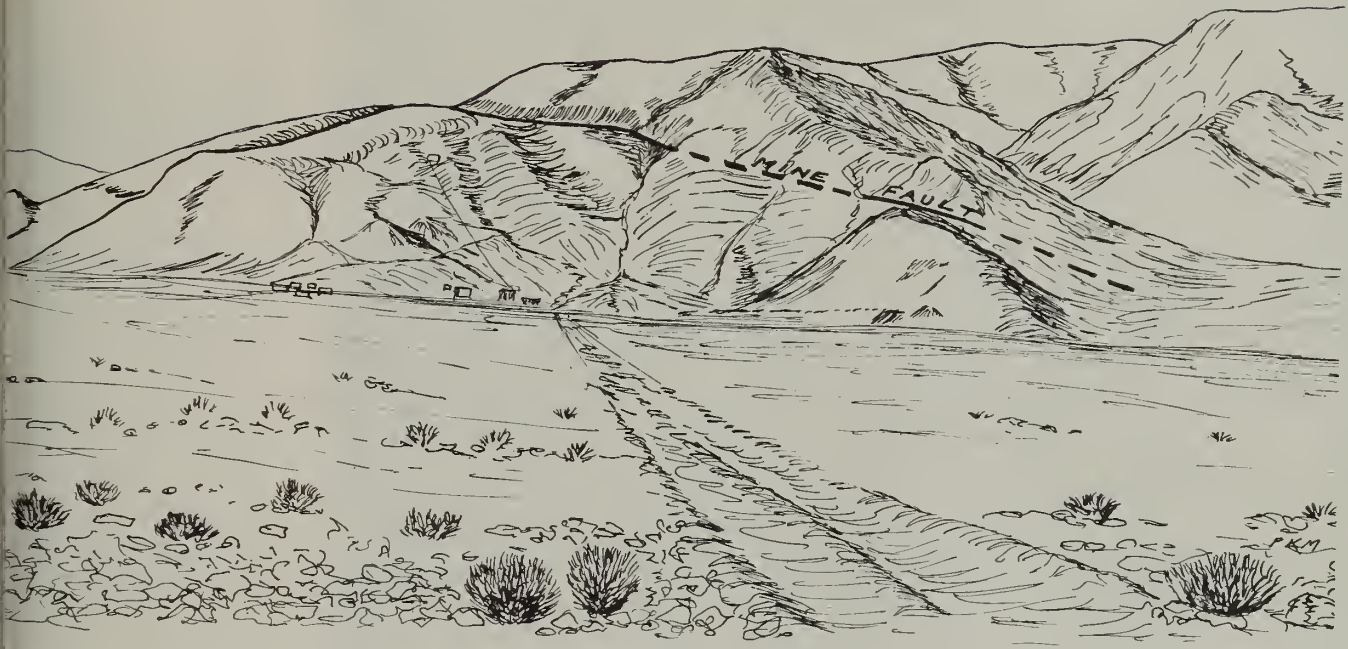
Structure

The principal structural features of the Queen
Sheba mine area are 1) northeast-trending faults,
northwest-trending normal faults, and 3) masses
Noonday Dolomite of probable land-slide origin.
northeast-trending faults separate the dolomite ma
and cut the northwest-trending faults. The northw
trending faults occur principally within the dolo
masses where they cut ore bodies in both deposits,
may in part be related to landsliding. Two of the t
masses of Noonday Dolomite contain highly brecci
zones, but the third contains relatively unbroken
which dip moderately northeast.

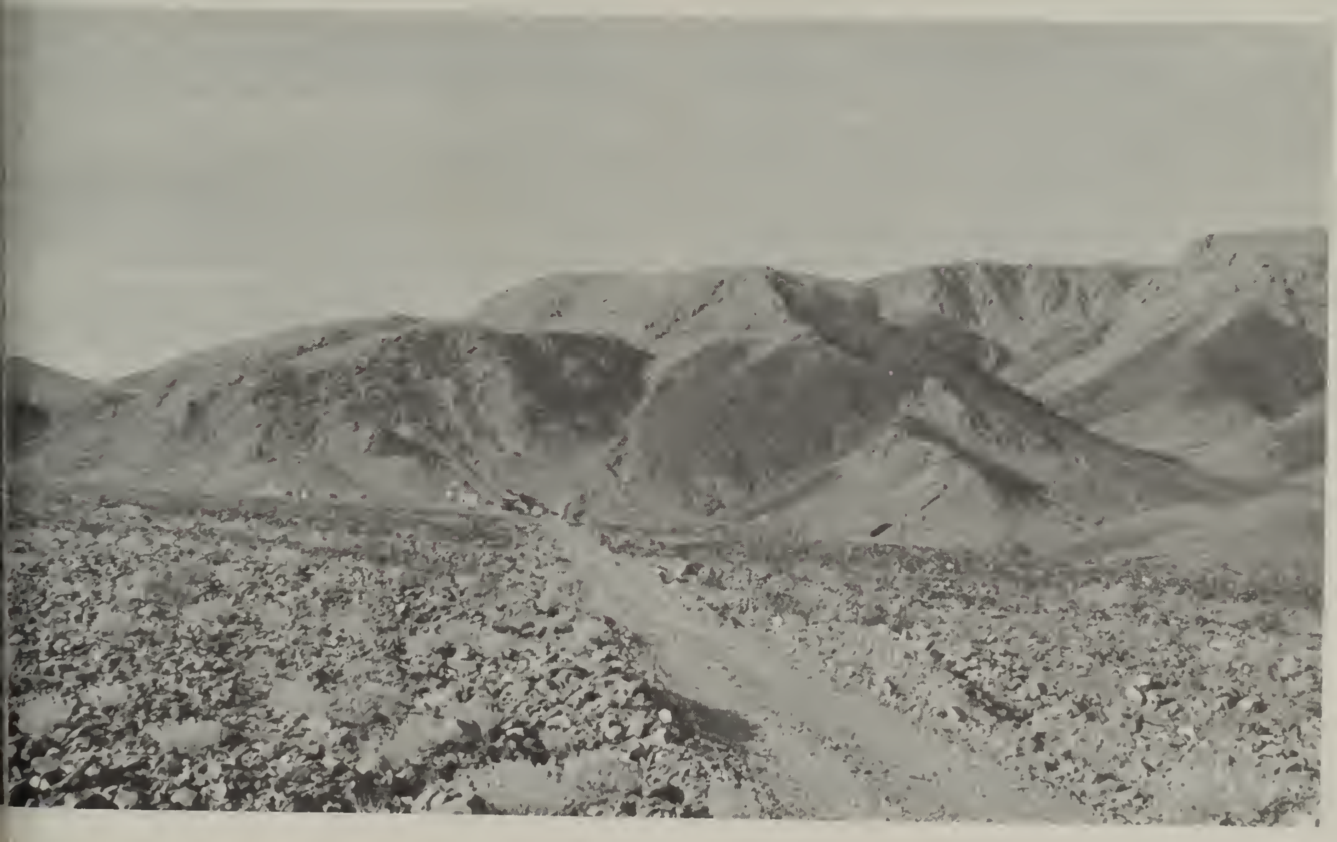
Faults. The set of northeast-trending faults co
of three principal faults here designated 1) the
fault, which traverses the west part of the mapped
2) the Sheba fault, which is 800 to 1100 feet east o
Mine fault and barely east of the Queen of Sheba
posit, and 3) a probable third fault, which appea
branch east-northeastward from the Mine Fault bet
the two ore deposits.

The most prominent of these faults is the Mine
which strikes about N.25°E. across the west part o
area and is vertical (fig. 3). Topographically it sepa
a large flat area west of the Queen of Sheba wor
from the higher ridge to the northwest outside
mapped area. The fault trace extends southwestwa
least half a mile beyond the mapped area, and pr
beneath Recent fanglomerate just beyond the nort
of the mapped area. Exposed northwest of the fa
Noonday Dolomite that is brecciated adjacent to its
tact with underlying diabase; southeast of the fa
higher and unbrecciated part of the dolomite is ex
thus indicating that the southeast block has been d
dropped. Northeast from the west side of the are
fault extends into diabase where its trace is nearly ob
except for exposures in a pronounced saddle in th
row east-trending ridge at the north edge of the

The Sheba fault strikes N.15°E. and dips steeply
west. It borders the west edge of a small flat s
developed on Noonday Dolomite southeast of the
of Sheba workings, and transects the Lower Cross
the eastern part of those workings. The small flat s



ure 3. Sketch and photo showing the trace of the mine fault. View is towards the southwest. Queen of Sheba workings are at left-center and Carbonate workings are at right-center.



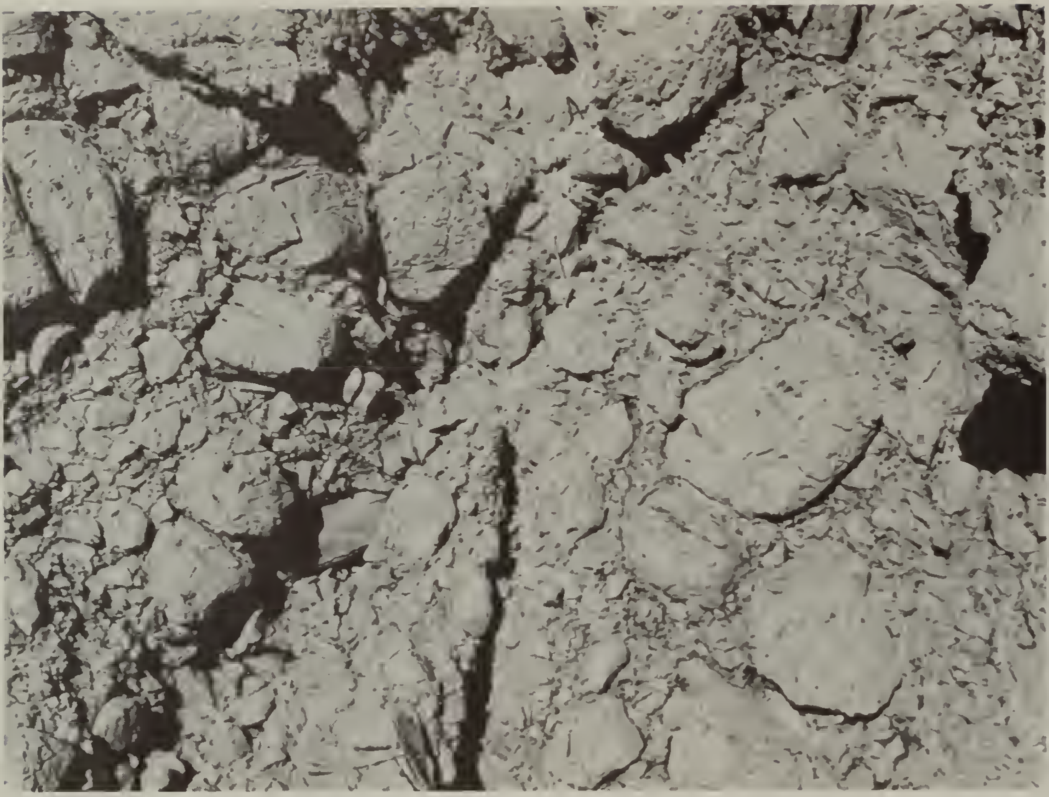


Figure 4. Photo of weathered face of landslide breccia in N day Dolomite. Larger clasts about 4 inches across.

appears to be a down-dropped segment of the larger flat surface that lies to the west between the Sheba and Mine faults. If this is true, then the Sheba fault is a reverse fault having a net dip-slip offset of at least 150 feet.

The third fault of this set follows the sharp ravine lying between the Carbonate and Queen of Sheba workings. It trends N.70°E. and appears to be vertical. Noonday Dolomite south of the ravine is apparently displaced downward relative to diabase north of the ravine. Although the fault zone is not exposed, the strike of bedding planes in the dolomite project across the ravine into the diabase. Also narrow, possibly sympathetic, shear zones lie parallel to and within several feet of the contact in the diabase north of the ravine.

The northwest-trending faults cut brecciated Noonday Dolomite in the Carbonate workings and cut the ore zone in the Queen of Sheba workings. These are in turn cut by the northeast-trending faults just described.

The northwest-trending faults strike N.20°–60°W. and dip steeply northeast or southwest. Displacement along these faults is generally in the nature of a few tens of feet—somewhat less than that of the northeast-trending set.

The most prominent northwest-trending fault, here named the Clay fault, intersects the ore zone in the Queen of Sheba workings. It strikes N.60°W. and dips 80° southwestward. The Clay fault has little or no surface expression and yet, underground, appears to cut off the ore zone and contains about 5 feet of clayey gouge—thus suggesting considerable movement. The mined zone occurs in the hanging wall side of the fault. two occurrences are known that could be the displa segment of the ore zone. One is a zone, weakly mi alized with galena, downslope and several tens of east of the main Queen of Sheba workings (plate 1, c section A-A′); the other is the occurrence of scatt blebs of galena nearly adjacent to the exposure of Clay fault in the Lower Crosscut.

No conclusive evidence was found to indicate certainty that the fault is post-mineral; no drag o evident within the gouge, nor is there any evidence the fault itself is mineralized. The ore zone appea be cut off abruptly, but the relationships in the pr workings are too obscure to determine whether the displaced the ore, or whether it merely formed an penetrable barrier to the mineralizing agency.

The evidence presented favors the conclusion tha fault is post-ore and that the displaced segment is occurrence downslope and east of the workings. being true, then movement on the Clay fault is no

Landslide masses. Two additional structural prob arising from the study of the Queen of Sheba min the questions of origin of the brecciated masses of N day Dolomite, and the structural relationship of the masses to one another.

The Carbonate ore body is contained in the sm of the brecciated masses, and the Carbonate mine w

re 5. Photo showing drag ore the fault zone of the East ult zone on the 904 level. rger fragment of galena ore about 5 inches across.

ng afford a view of the internal structure of the mass s well as its contact with the underlying diabase. The s is composed predominantly of strongly recemented ngular fragments of dolomite which average about 3 nces in diameter, but which range in size from small ins to boulders 6 feet in diameter (fig. 4). Bedding lanes, where discernible in the larger fragments, appear e crudely oriented to an overall strike of N.30°W.–0°E., with a consistently eastward dip at moderate eep angles. The bedding is highly discordant to the ntact with the underlying diabase. This contact, which ell exposed in the lowest part of the Carbonate working (816 level), is a broadly undulate surface of movent that strikes generally northwest and dips about 25) degrees northeastward. Exposures of the surface in e northeastern part of the 816 level, however, dip utheastward. The contact is marked by a gouge zone proximately 1 foot thick, containing an upper layer nely fragmented dolomite and a minor lower layer he diabase fragments. The two rock types are relavely unmixed within the zone. Although the underlying ase that is near the finely fragmented zone is relavely undisturbed, it is fractured into large uncemented gular blocks some of which are separated by open actures.

Several northwest-trending faults that dip 40–75 derees eastward, both east and west of the Carbonate ore ody, cut the Noonday Dolomite but not the underlying ase. These faults have offset the ore body and delimit, to a large extent, various parts of it. The fault planes are sharply defined and are bordered by zones of gouge and drag as wide as six or eight feet. Even though these zones are prominent they could not be traced more than several tens of feet along either their strike or dip.

Several of these faults are well exposed on the 904 level (see pl. 2) where one of them, here named the East fault, intersects a narrow ore zone. The East fault strikes N.10°W., dips 65–75 degrees northeast and is about 5 feet wide where it intersects the ore zone. North of the intersection, drag ore is present along the plane of the fault (fig. 5) for at least 30 feet northward. The fault zone, exposed in a winze from the 904 level, dwindles within 50 feet downward to a zone too weak to be traced. Drag ore was observed in the fault zone to a depth of 25 feet below the sill of the winze. This fact, coupled with the attitude of the orebody and the northward drag, indicates normal movement. From the point on the 904 level where it cuts the ore zone, the fault can be traced less than 100 feet southeastward and 60–70 feet northwest (see pl. 2). It is obscure on the surface about 30 feet above the 904 level and does not appear to extend to the 816 level. A smaller parallel fault about 10 feet west of the East fault is exposed at the surface in a raise from the 904 level.

The mass of Noonday Dolomite that lies along the western boundary of the mapped area appears to be brecciated to about the same degree as the mass just described, but only within a few tens of feet of its contact with underlying diabase. The beds above the breccia appear to be intact and concordant with the lower contact. The internal features of the mass were not observed because of the absence of mine workings in it. Its contact with underlying diabase is mostly obscured by talus.

The third and largest mass of Noonday Dolomite, which contains the Queen of Sheba ore deposit, is a relatively unbrecciated, crudely homoclinal mass. The strata in the mass strike mostly N.20°–45°W. and dip 30°–50° northeast. Beds in the southern part of the mass strike about N.30°W. and dip 30° northeast. Farther northwest the beds steepen slightly and swing more northwestward to maximums of N.55°W. strike and 50° northeast dip in the area just northwest of the Queen of Sheba workings. An anticline of gentle flaxure and short axis is apparent on the large flat area a few hundred feet west of the Queen of Sheba workings. The axis of the fold trends northwest to northwest by west. The Mine fault transects its southwest limb.

The evidence presented above suggests that the brecciation in the smaller mass is of landslide origin, and that the mass probably moved from the southwest as an essentially intact block which, in the course of movement, was fractured and contorted so that only the grosser of its internal features were retained. The northwest-trending faults that cut the mass do not extend into the overridden diabase and are not disrupted by the landslide; hence they probably formed concomitantly with the landslide activity; or possibly, they are the result of later adjustment within the mass. Quite possibly, the smaller mass was a part of the unbrecciated mass described above and has since been separated from it as a result of landslide movement and subsequent erosion.

The unbrecciated mass of dolomite probably represents a higher section in the Noonday Dolomite than is exposed in the larger western, brecciated mass northwest of the Mine fault, and presumably overlies a lower but concealed brecciated zone similar to that exposed at the base of that mass. These brecciated zones may have been formed as the result of incompetence of the dolomite during periods of regional deformation, because they are commonly present at the base of the Noonday Dolomite throughout the Death Valley region (B. W. Troxel, personal communication, 1962). They would, therefore, be unrelated to the breccia caused by landsliding.

Landslide movement post-dates mineralization because the Carbonate ore body is itself brecciated and contorted. Landslide movement post-dates the northeast-trending fault activity, because the Mine fault does not appear to truncate the landslide surface. Although the age of the Mine fault is uncertain, an older limit can be ascribed to its age if we can assume the flat erosional surfaces developed on top of the two larger masses of Noonday
Dolomite are remnants of the Pliocene Darwin Senesla
surface of Maxson (1950). Under this assumption,
Mine fault is post-Pliocene in age because it separa
this once-continuous surface. The post-fault landsli
then, would also be post-Pliocene. This line of reason
is weakened by the lack of any firm basis for assign
the flat surfaces to the Darwin Senesland.

The younger age limit is equally difficult to establ
It probably is not a relatively recent feature beca
some of the morphologic features that characterize rec
landslides are absent: no transverse fractures are pres
at the surface; no obvious source area is apparent;
features are obscure; and the mass is completely
cemented into one cohesive block. Moreover, no
placement of the younger alluvium around the slid
evident. It is reasonable to postulate that these featu
if formerly present, have been eroded away since
landslide activity, although the duration of the per
is difficult to establish. Furthermore, carbonate rock s
as Noonday Dolomite does not erode rapidly in an
climate. It is concluded therefore that the slide proba
did not occur during historic time.

ORE DEPOSITS

The two ore deposits at the Queen of Sheba mi
the Queen of Sheba, and the Carbonate deposits—are
placement bodies in two structurally distinct masse
dolomite. The Carbonate body has been strongly b
ciated and contains mostly oxidized ore minerals.
Queen of Sheba ore body, on the other hand, is relati
unbroken and contains mostly primary ore minerals.

Queen of Sheba deposit. The Queen of Sheba dep
the less productive of the two deposits, is a replacen
zone along favorable strata in Noonday Dolomite, w
strike about N.50°W. and dip 25–30°NE. The zone c
out on the upper northeast face of the larger spur in
mapped area and extends northwestward from the sm
flat on the crest of the spur. The mineralized zon
approximately 40 feet thick and contains small irreg
pockets of lead minerals occurring at scattered inte
along an exposed strike distance of about 200 feet
a known distance of 400 feet along the dip.

The hanging wall of the ore zone is not clearly defi
but the footwall is distinct at its only exposed poi
Crosscut No. 3, the highest level (elevation 1,321 f
There, it is a bedding plane in Noonday Dolomite w
strikes N.50°W. and dips 25°NE. Lead mineraliz
appears to have halted abruptly along this plane
only occasional tiny blebs of galena occurring w
1 foot or 2 feet below it. In Crosscut No. 2, below
vation 1,304 feet), the lower part of the ore zone is
exposed because it is offset by a fault that strikes a
N.5°W. and dips steeply eastward (see pl. 3). The

*le 1. Minerals identified from the Queen of Sheba mine, in approximate order of abundance.**

Primary	*Secondary*
minerals:	Ore minerals:
lena—PbS	cerussite—$PbCO_3$
trahedrite(?)—$Cu_2S \cdot Sb_2S_3$	anglesite—$PbSO_4$
alcopyrite—$CuFeS_2$	plattnerite—PbO_2
genite(?)—$Cu_{2-x}S$	minium—$PbO \cdot PbO_2$
gue minerals:	chrysocolla—$CuSiO_3 \cdot 3H_2O$
	lorettoite—$PbCl_2 \cdot 6PbO$
lomite—$CaMg(CO_3)_2$	plumbojarosite(?)—
artz—SiO_2	$PbFe_6(OH)_{12}(SO_4)_4$
lcite—$CaCO_3$	covellite—CuS
rite—FeS_2	
ricite—$H_2KAl_3(SiO_4)_3$	Gangue minerals:
	limonite—$2Fe_2O_3 \cdot 3H_2O$
	goethite—$Fe_2O_3 \cdot H_2O$
	calcite—$CaCO_3$
	hematite—Fe_2O_3
	clay minerals
	manganese oxides

s table is not the result of an exhaustive study. Undoubtedly other minerals are present.

t is exposed at the face of Crosscut No. 3 about 20 southwest of the footwall exposure of the ore zone, in Crosscut No. 1, (elevation 1,272 feet) about 90 from the portal. The ore zone was not encountered hat level because it was offset by movement on the fault. The fault that trends N.5°W. does not ap- to extend to the Lower Crosscut (elevation 1,157 unless it is one of several minor faults exposed there.

ne ore zone is cut by several small faults that trend °E. and dip steeply northwest. These faults are arked by shear zones commonly less than 6 inches . Lead mineralization appears to be most intense djacent to these faults. One such fault occurs adjacent ne eastern margin of the principal ore shoot. The of intersection of the fault with the favorable strata esponds approximately to the plunge of the ore shoot, dating that the fault exerted some control over the acement of the ore minerals. Perhaps this fault, and rs, were the channels through which the ore solu- migrated from their source.

oxidized parts of the ore zone are simple mineralo- y. The primary ore is composed chiefly of galena minor proportions of very fine-grained pyrite and red small grains of chalcopyrite in a gangue of ite, calcite, and minor quartz (see table 1). Scat- te patches of an unidentified black sulfide containing per, lead, antimony, iron, and vanadium(?) are not uncommon. X-ray diffraction patterns indicate that this material may be a mixture of galena, tetrahedrite and digenite. Semi-quantitative data obtained from galena samples indicate that most of the silver is present in the galena itself, presumably as fine intergrowths of silver minerals, although none were detected in polished section or in x-ray determinations. No zinc minerals were noted, although a composite sample of ore taken by lessees from these workings during 1952 was reported to assay 0.2 percent zinc. Zinc was detected only as a trace element in an aggregate of sulfide samples collected during this study (see table 3). Most of the galena is unoxidized even in surface exposures, although cerussite makes up a substantial proportion of some ore pockets. Copper minerals also are mostly unoxidized. The occurrence of unoxidized ore minerals, even near the surface, may reflect the low permeability of the dolomite, or perhaps that the Queen of Sheba ore body has only comparatively recently been exposed to weathering.

2. X-ray spectrographic analyses of sulfide ore (QS) and oxide ore (QSO) from the Queen of Sheba ore body.

	Sample QS	*Sample QSO*
r than 0.5%	Pb, Fe	Fe, Pb
00 ppm	Cu, Sb, Ag, Mg	Zn, Mg, Cu^-
an 200 ppm *	Si, Zn, As, Ni, Al, Sn, Cr	Ag^+, As, Sb, Si, Sn, Al

than 400 ppm for Zn and As)
+ nd — represent extreme relative positions within range)

The principal secondary minerals contained in the Queen of Sheba workings are cerussite, anglesite, plattnerite, plumbojarosite (?), and hydrous iron oxides.

Table 3. Spectographic analyses of 4 galena samples.

	C	*M*	*S′*	*S″*
Ag	0.145%	0.11%	0.13%	0.12%
Cu	200	tr–10	300–400	1000
Zn	200	tr.	–	–
Al	101–1000	101–1000	101–1000	101–1000
Sb	101–1000	101–1000	101–1000	101–1000
Sr	101–1000	101–1000	101–1000	101–1000
Ni	11–100	tr–10	11–100	tr–10
Cr	11–100	tr–10	11–100	tr–10
Sn	11–100	11–100	11–100	11–100
Mg	11–100	–	–	–
Fe	11–100	tr–10	11–100	11–100
Ti	tr–10	tr–10	tr–10	tr–10
Mn	tr–10	tr	tr	tr
Zr	tr	tr	tr	tr

Sample C—Main stope, Carbonate workings
M—Mineralized pod, 500 ft. NWW of Crosscut No. 3 portal
S′—Stope 3–2, Crosscut No. 3
S″—Stope 3–1, Crosscut No. 3
Ag in percent; all others in ppm.

Little alteration of the dolomite between the ore bodies is evident. These intervening zones are characterized by scattered blebs of galena ¼ to ½ inch in maximum diameter, lesser amounts of galena in narrow discontinuous veinlets, and very widely disseminated tiny crystals of pyrite.

The principal ore body was mined from a stope (3–1) that extended from Crosscut No. 3, the highest level (elevation 1,321 feet) to the surface (elevation 1,350 feet). Judging from the shape of the stope, the ore occurred in a tabular body 3 to 5 feet thick normal to the bedding, 20 feet wide, and about 70 feet long along its axis which trends N.15°W. and plunges 20° northwest along a bedding plane. Another ore body on the same level but about 30 feet west of the other, was

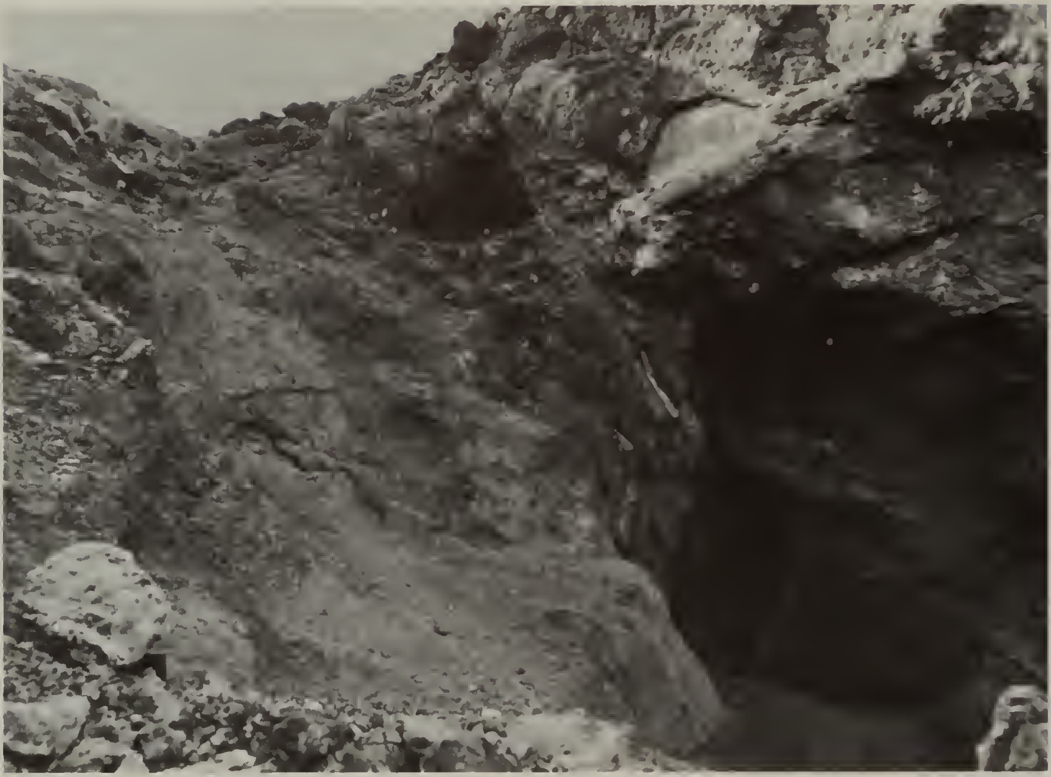


Figure 6. Photo showing uppe
of Carbonate ore body termi
against the West fault (
zone in left-center). View

slightly lower in the favorable strata. It was apparently 4 to 6 feet thick normal to the beds, 10 feet wide along the strike, and 30 feet long along its axis which trends N.10°E. and plunges 35° northeast, slightly steeper than the bedding in the dolomite.

Carbonate deposit. The Carbonate ore body is a faulted brecciated body which lies within the landslid, or smallest, mass of Noonday Dolomite. Ore concentrations within it have been largely mined out, but the shape and configuration of the stopes and the presence of faults in hanging and footwalls indicate that the ore bodies are faulted segments of brecciated, bedding-plane replacement zones which were originally much the same in nature as those of the Queen of Sheba ore body.

The Carbonate ore body consists essentially of two disjointed but adjacent, lenticular segments separated by faults. The south and larger segment strikes generally N.10°W., dips 40° northeast, and is highly irregular in shape. It measured about 100 feet along the strike, 60 feet along the dip, and as much as 20 feet in thickness. The smaller segment is elongate, strikes north, dips moderately eastward, and plunges 20° to the northeast. It was about 100 feet long, 5 to 10 feet wide, and about 10 feet thick. (Sizes of the ore bodies were estimated by observing the stopes.) The northwestern end of the southern and larger segment appears to terminate near the southern end of the north segment. The southern segment is bounded on the northeast and southwest by the Carbonate and West faults (fig. 6), which strike nearly parallel
to the strike of the ore body (see pl. 2). The nort
segment lies along the east side of the Pit fault, w
strikes due north and dips about 65 degrees east.
three faults apparently strike roughly parallel to the
eral strike of the bedding plane replacement zone, w
in the course of landsliding has become rather obsc
The faults, however, dip more steeply than the ore
ies. The faults, as discussed under Landslide Masses
probably related to landsliding.

The ore in the Carbonate workings occurs as disc
angular fragments of mineralized dolomite mixed
fragments of unmineralized dolomite. Fragments r
in size from about 8 inches to less than 1 inch in g
est dimension. Secondary minerals greatly predom
over primary minerals, which are identical to tho
the Queen of Sheba deposit. Secondary minerals inc
mainly cerussite but also anglesite, plattnerite, mir
plumbojarosite(?), and chrysocolla (see table 1). Ga
minerals include dolomite, calcite, quartz, pyrite,
drous iron oxides and sericite. Near the surface, ore
erals are oxidized, partly leached, and redeposited i
interstices of the fragments of dolomite. Some ore
tains galena that was deposited in the interstices of
grained breccia that is known to be pre-landslide;
ments of it are contained in the much coarser br
caused by the landsliding activity.

The great predominance of oxide minerals ove
mary minerals in the Carbonate ore body may b
tributable either to the high porosity of the brec

s, or to exposure of the Carbonate ore body to thering before the ore body was displaced from its ner position. The relative paucity of oxide minerals e Queen of Sheba ore body, on the other hand, may cate, as previously suggested, that the Queen of a ore body was not exposed to weathering before andslide activity. This evidence lends credence to the ibility that the Carbonate ore body is an upper, dised, part of the Queen of Sheba ore body.

CONCLUSIONS AND SUGGESTIONS FOR PROSPECTING

ssibilities of finding additional ore at the Queen of a workings are few. Among the most favorable areas ospect are extensions of the known ore zone both lly and along the dip. The area northwest of the ipal workings is little explored even though the ore may be projected into that area. The two most able sites to explore there are near the two occur- s of galena noted on the map. These could be ex- d most economically by core drilling.

e may exist also on the level of Crosscut No. 3 along rojected intersection of the footwall part of the ore and the fault that is on the east margin of the prin- ore body. The intersection of that fault with the ng wall part of the zone is the locus of the princi- e body; the corresponding footwall intersection, ore, offers a reasonable possibility for ore. This in- tion on the level of Crosscut No. 3 projects to a about 100 feet S.50°E. from the footwall exposure he face of the crosscut.

ee slightly less favorable, though potentially re- ng, areas to explore are (1) between the two flat southwest of the workings, for a southeastward ion of the ore zone; (2) beneath the larger of the eas, for an up-dip extension of the ore zone; and st of the Sheba fault, for the downfaulted exten- f the favorable stratigraphic zone. One drill hole area should be sufficient to test for a mineralized with further drilling dependent upon positive re- s. The first of the above three areas was explored 1952 by drilling 5 shallow wagon-drill holes, with e results. These holes, however, were drilled to mum depth of only 47 feet. Holes in this area be at least 100 feet deep in order to test the pos- of a projected extension of the ore zone.

discovery of additional large ore bodies near the ate workings is unlikely because the ore body n thoroughly explored below its mined limits, and hly improbable that extensions of the ore body found in the underlying diabase. Even if the dolo- d been mineralized in its present position, it is that ore would be found in the underlying dia- cause it has proved to be an unfavorable host r lead deposits throughout the Death Valley region. Furthermore, no indications of mineralization in the diabase were noted in this study. It is not likely that any large ore bodies exist either east or west of the Carbonate workings because most of the Noonday Dolomite is well exposed and thin. The possibilities for finding minor ore pockets, however, are somewhat more favorable, especially immediately east and west of the known ore horizon, and below outcrops where galena occurs in narrow black manganese-stained quartz stringers.

Outside the mapped area, both locally and throughout the Panamint Range, exploratory possibilities are favorable. A conclusion gained from the study of the Queen of Sheba mine is that the source area of the landslide would be a very favorable one to explore, providing of course that it did not originate at the Queen of Sheba ore body. In order to determine where this might be, a study must be made of the surrounding areas. Evidence in the mine area suggests that the landslid masses moved from the west or southwest. The original site of mineralization may have been removed by erosion, however. Regardless of the landslide, areas underlain by Noonday Dolomite to the west and southwest of the mine remain favorable areas to explore. This is attested to by a discovery, subsequent to the mapping for this report, several hundred feet southwest of the mapped area. In 1962 the discovery was too little exposed to evaluate. Because the areas surrounding the Queen of Sheba mine have been examined at least superficially in the past without notice of this recent finding, further geologic investigation and subsurface exploration is in order. Moreover, the Queen of Sheba ore body and similar deposits have little surface expression, so are difficult to locate by traditional prospecting methods.

Ore solutions that formed the Queen of Sheba deposit are believed to have emanated from unexposed Mesozoic (?) granitic rocks similar to those exposed in the vicinity of Warm Spring Canyon, then to have followed faults or other channels to a favorable zone in the lower member of the Noonday Dolomite. Still, the possibility of a relationship between mineralization and Tertiary volcanic activity or Triassic intrusive volcanic rocks should not be overlooked. Why a distinct stratigraphic zone was favorable for deposition of lead at the Queen of Sheba deposit was not determined in this study, but that this favorable zone has undergone mineralization elsewhere in the range remains a distinct possibility. Carbonate rocks other than Noonday Dolomite may also have been receptive host rocks for mineralization, particularly if they were the first easily replaced rock intersected by the solutions. Other lead-silver deposits in the Panamint Range occur with great consistency in carbonate rocks. Almost all, however, are vein-type deposits, and most are in rocks of the Precambrian Pahrump Group. Few lead deposits have been found in Noonday Dolomite in the Panamint

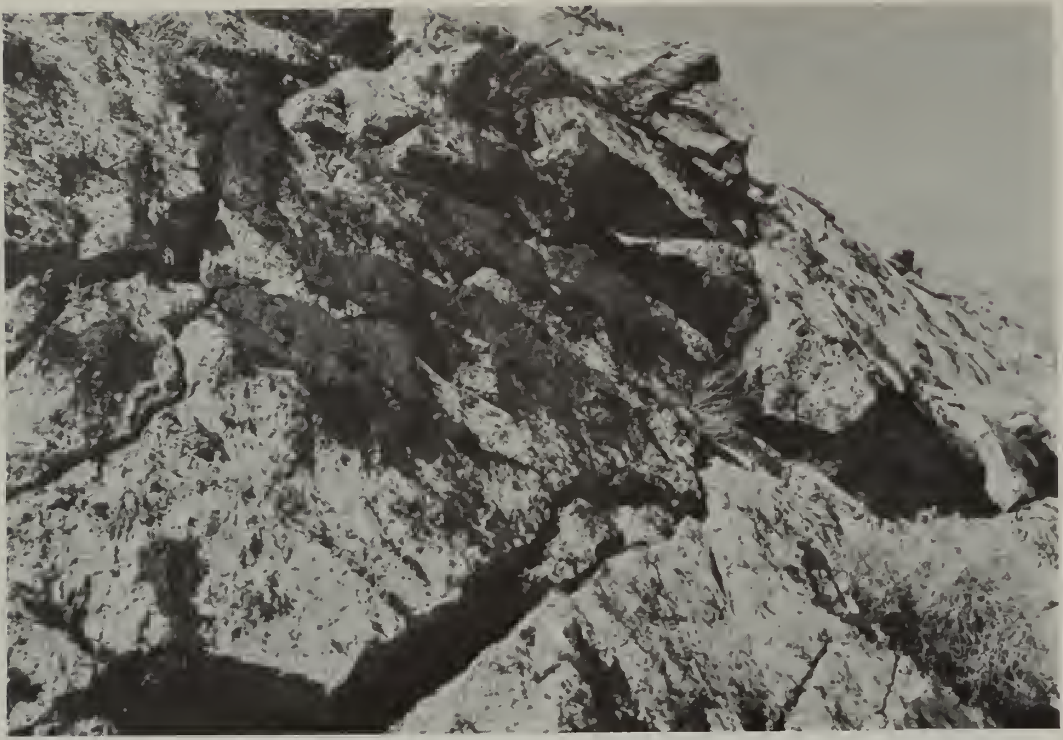


Figure 7. Photo of mon
stained quartz veinlet oc
along bedding plane in N
Dolomite near the Que
Sheba ore body. Bush at fo
is a foot high.

Range, but the Queen of Sheba mine and many deposits elsewhere in the Death Valley region attest to the high incidence of lead mineralization in this formation.

Geochemical sampling of the major drainage channels of the Panamint Range offers a new, promising tool as a rapid guide to the most favorable areas in which to prospect (Hawkes, 1962). The copper and silver associated with the lead deposits would be good tracer elements. Areas underlain by carbonate rocks that lie peripheral to bodies of Mesozoic granitic rocks are most favorable, although it should be borne in mind that the Queen of Sheba deposit is not directly adjacent to any exposed granitic rocks. On a more local level, the occurrence of black manganese-stained quartz veinlets (fig. 7) and iron-rich material in carbonate rocks might suggest favorable areas for exploration.

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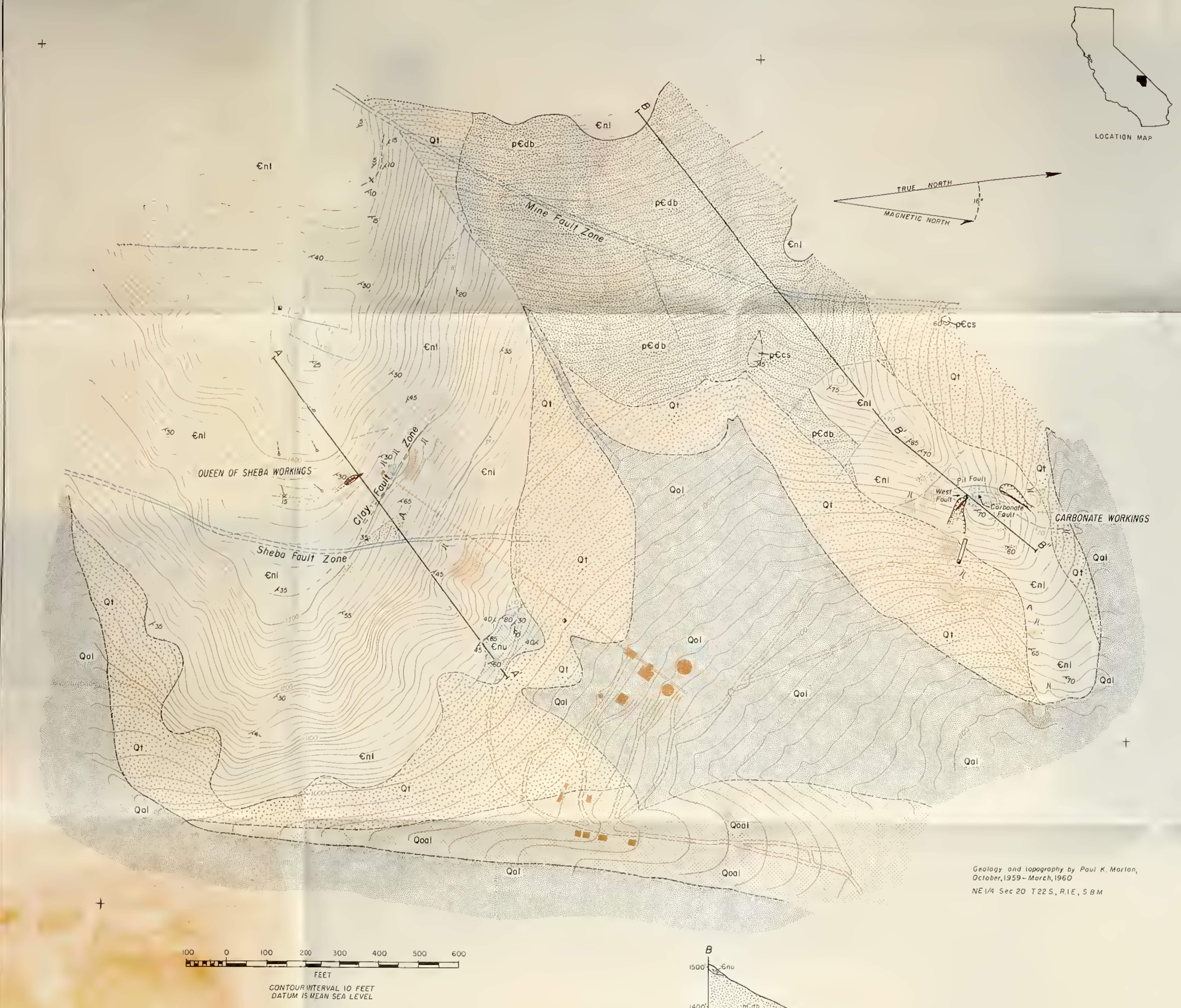


Geology and topography by Paul K. Morton,
October, 1959 – March, 1960

NE 1/4 Sec 20 T 22 S., R.1 E., S B M

EXPLANATION

Qal
Quaternary alluvium

Qt
Quaternary talus and slope wash

Qoal
Quaternary older alluvium

Ꞓnu
Cambrian (?) Noonday Dolomite, upper member

Ꞓnl
Cambrian (?) Noonday Dolomite, lower member

pꞒdb
Precambrian Crystal Spring Formation diabase

pꞒcs
Precambrian Crystal Spring Formation quartzite

Contact, dashed where approximate

Concealed contact

Fault showing dip, dashed where approximate, queried where conjectural

Fault zone showing dip, dashed where approximate

Concealed fault

Breccia

20
Dip and strike

Anticlinal axis, approximately located

Mineralized zone

Portal of adit

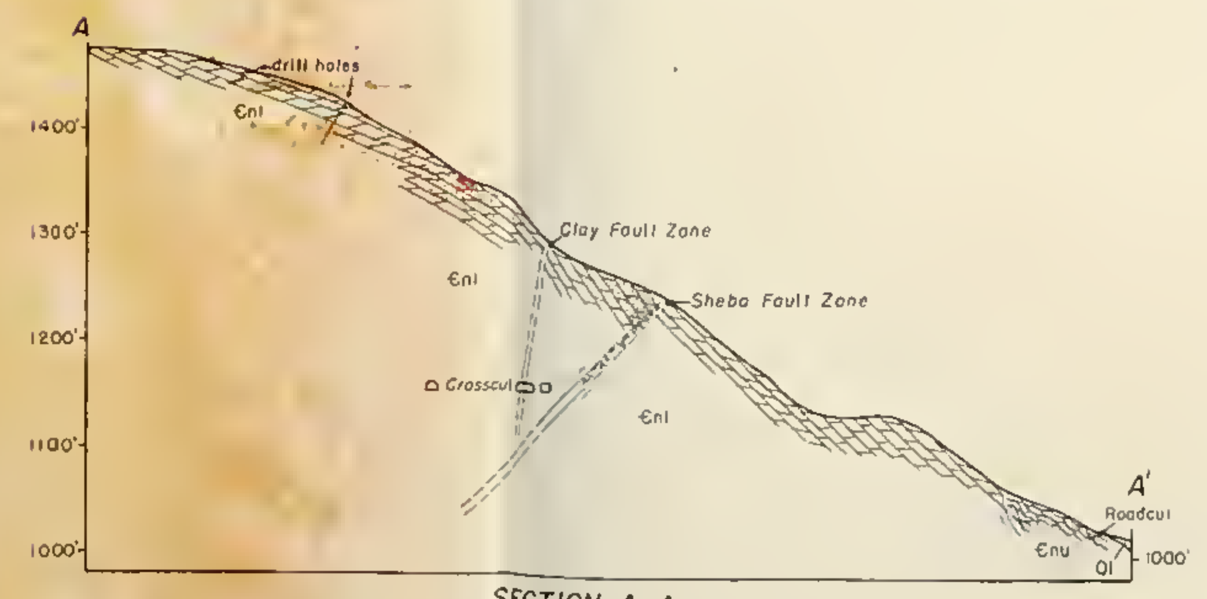
Pit or cut

Dump

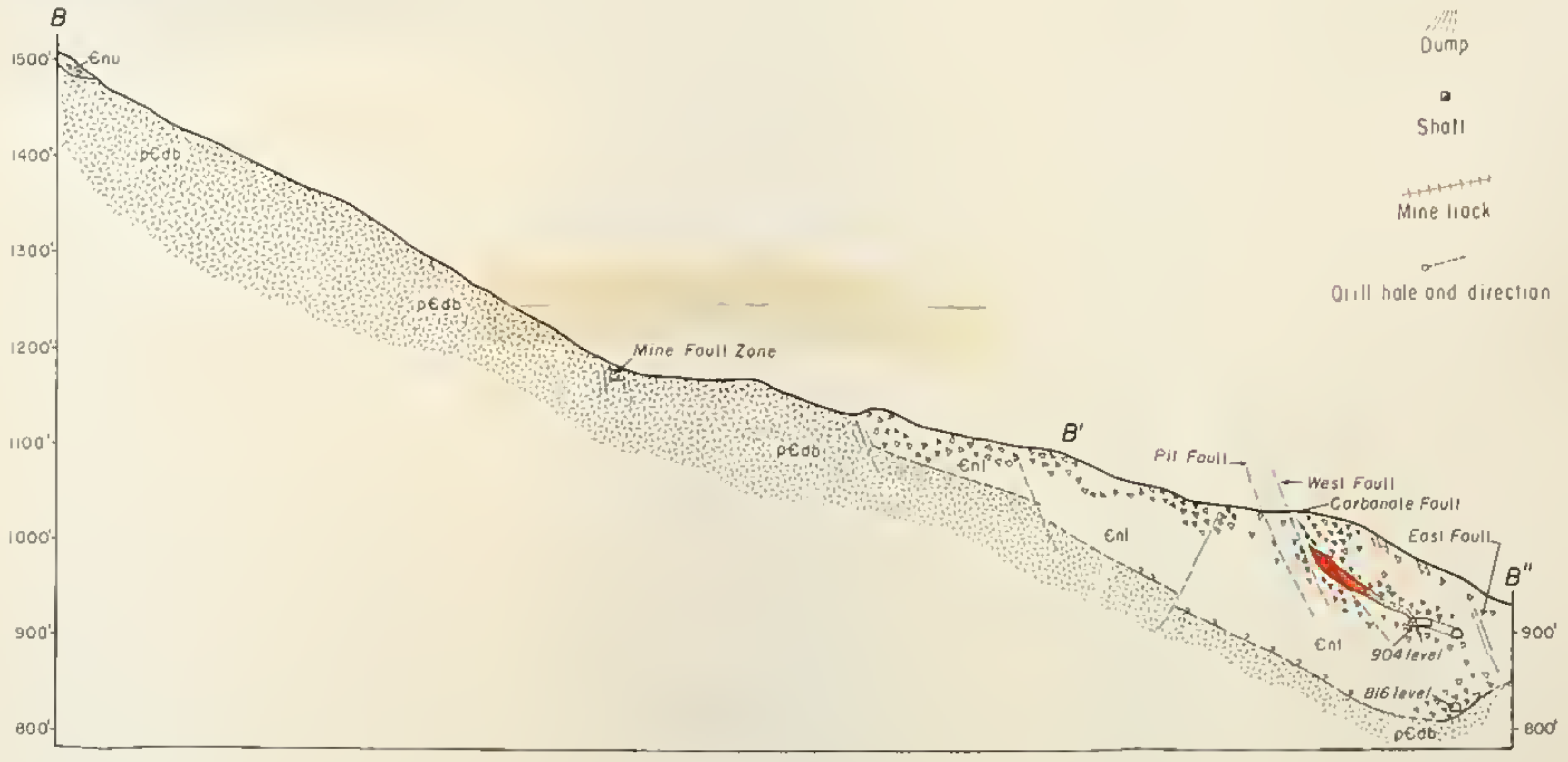
Shaft

Mine track

Drill hole and direction



SECTION A-A

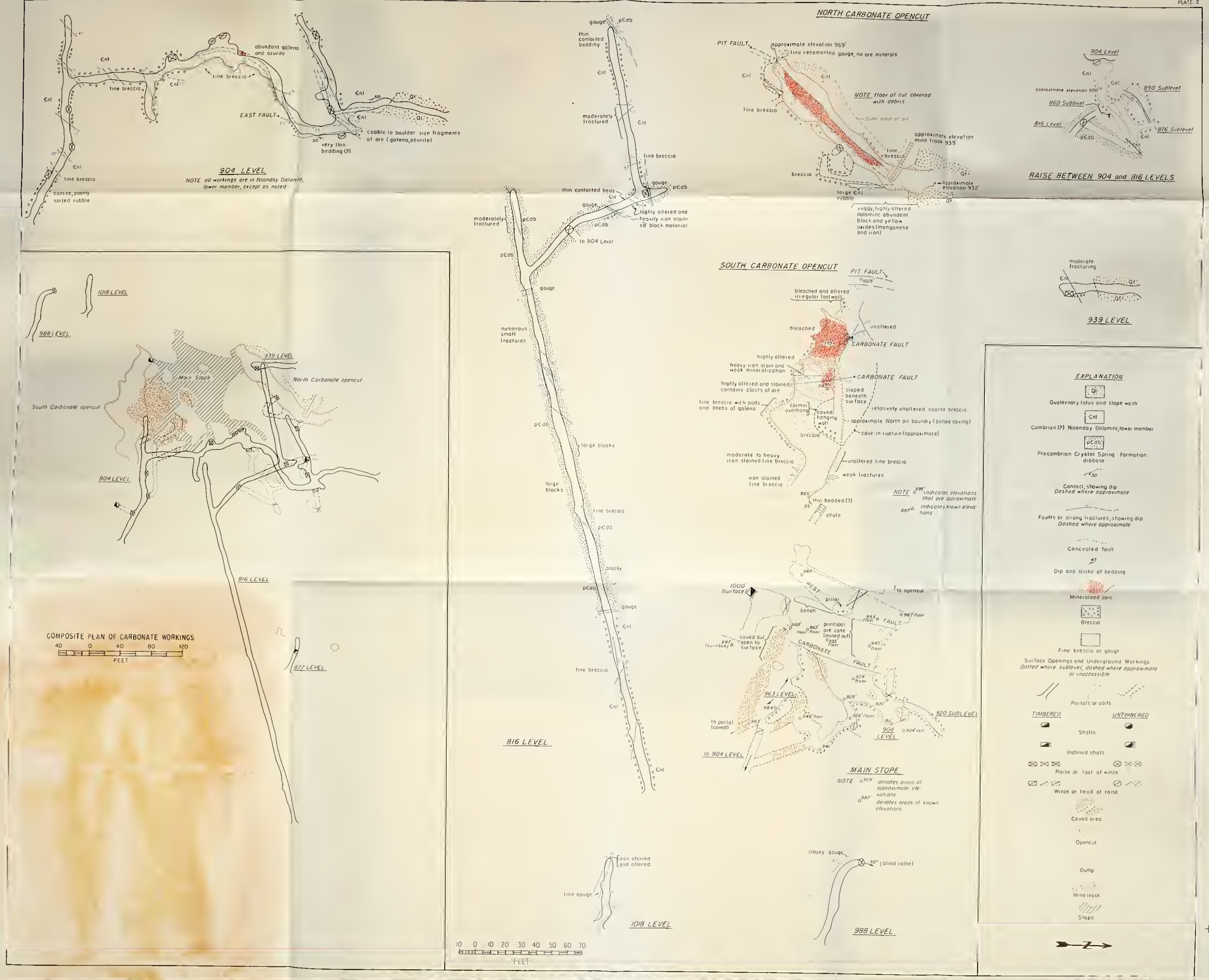


SECTION B-B'-B''

GEOLOGIC MAP AND SECTIONS OF THE QUEEN OF SHEBA MINE AREA
INYO COUNTY, CALIFORNIA

DIVISION OF MINES AND GEOLOGY
IAN CAMPBELL, STATE GEOLOGIST

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION


Ɛnl
fine breccia
abundant galena and azurite
fine breccia
EAST FAULT
Ql
cobble to boulder size fragments of ore (galena, azurite)
very thin bedding (?)
fine breccia
coarse, poorly sorted rubble
904 LEVEL
NOTE all workings are in Noonday Dolomite, lower member, except as noted
gouge
p€db
thin contorted bedding
moderately fractured
fine breccia
thin contorted beds
highly altered and heavily iron stained black material
to 904 Level
numerous small fractures
large blocks
blocky
Cnl
816 LEVEL
iron stained and altered
fine gouge
1018 LEVEL
NORTH CARBONATE OPENCUT
PIT FAULT
approximate elevation 969'
fine recemented gouge, no ore minerals
NOTE floor of cut covered with debris
Outer limit of pit
approximate elevation mine track 939'
breccia
large Ɛnl rubble
approximate elevation 932'
vuggy, highly altered dolomite abundant black and yellow oxides (manganese and iron)
904 Level
approximate elevation 900'
890 Sublevel
860 Sublevel
816 Level
876 Sublevel
RAISE BETWEEN 904 and 816 LEVELS
moderate fracturing
939 LEVEL
SOUTH CARBONATE OPENCUT
1025'
bleached and altered irregular footwall
bleached
unaltered
CARBONATE FAULT
highly altered
heavy iron stain and weak mineralization
highly altered and stained, contains clasts of ore
fine breccia with pods and blebs of galena
former overhang
caved hanging wall
stoped beneath surface
relatively unaltered coarse breccia
approximate North pit boundry (before caving)
cave-in rupture (approximate)
moderate to heavy iron stained fine breccia
unaltered fine breccia
weak fractures
iron stained fine breccia
thin bedded (?)
chute
NOTE 995' indicates elevations that are approximate
987' indicates known elevations
1000' (surface)
WEST FAULT
pillar
bench
to opencut
principal ore zone (mined out)
caved but open to surface
987' (surface)
963 LEVEL
to portal (caved)
to 904 LEVEL
920 SUBLEVEL
904 LEVEL
904 rail
MAIN STOPE
NOTE 929' denotes areas of approximate elevations
987' denotes areas of known elevations
clayey gouge
50° (blind raise)
988 LEVEL
1018 LEVEL
988 LEVEL
939 LEVEL
Main Stope
North Carbonate opencut
South Carbonate opencut
904 LEVEL
816 LEVEL
877 LEVEL
COMPOSITE PLAN OF CARBONATE WORKINGS
40 0 40 80 120
FEET
10 0 10 20 30 40 50 60 70
FEET
EXPLANATION
Ql
Quaternary talus and slope wash
Cnl
Cambrian (?) Noonday Dolomite, lower member
p€db
Precambrian Crystal Spring Formation diabase
Contact, showing dip
Dashed where approximate
Faults or strong fractures, showing dip
Dashed where approximate
Concealed fault
Dip and strike of bedding
Mineralized zone
Breccia
Fine breccia or gouge
Surface Openings and Underground Workings
Dotted where sublevel, dashed where approximate or inaccessible
Portals or adits
TIMBERED
UNTIMBERED
Shafts
Inclined shaft
Raise or foot of winze
Winze or head of raise
Caved area
Opencut
Dump
Mine track
Stope
N

GEOLOGIC MAPS OF THE CARBONATE WORKINGS

DIVISION OF MINES AND GEOLOGY
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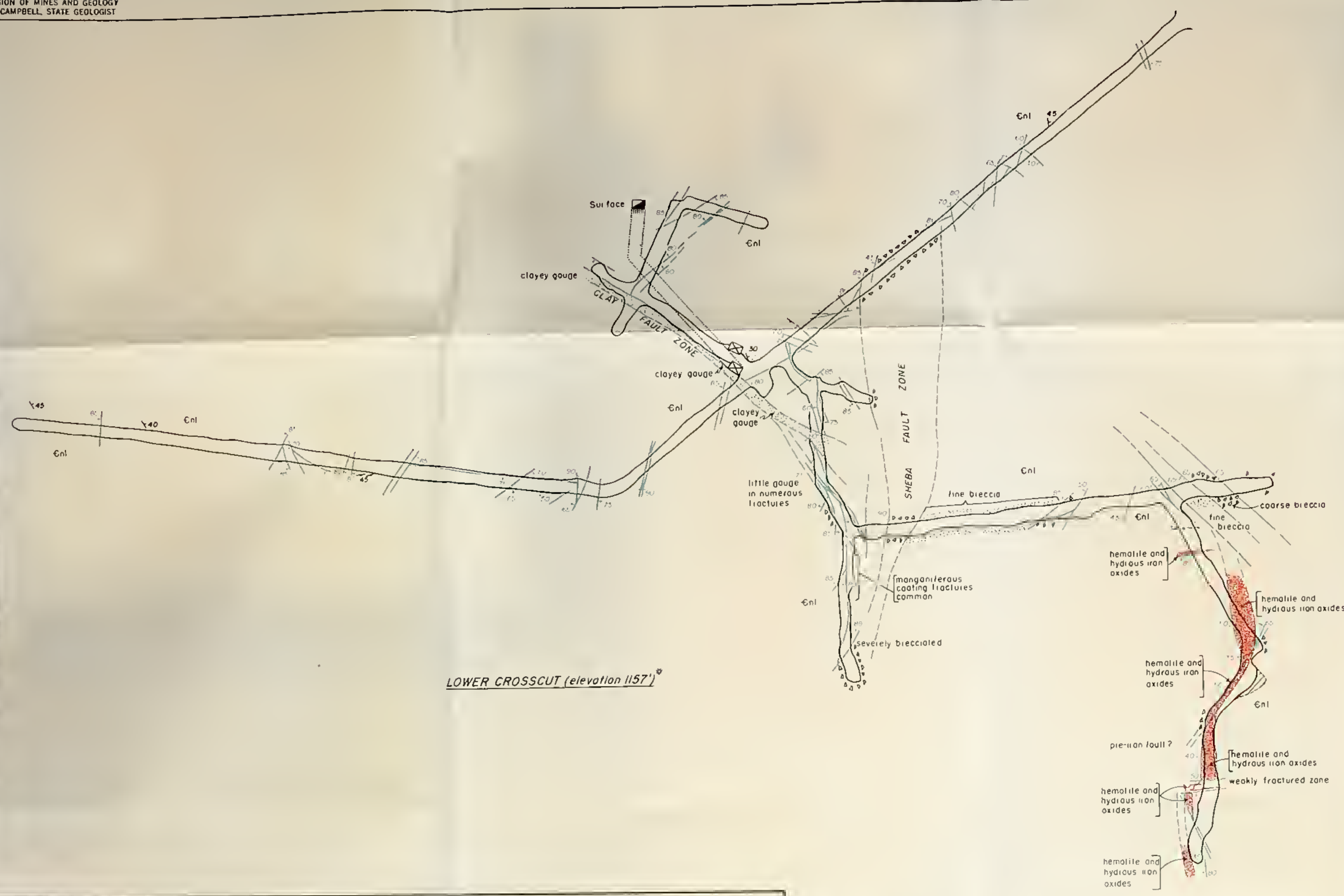
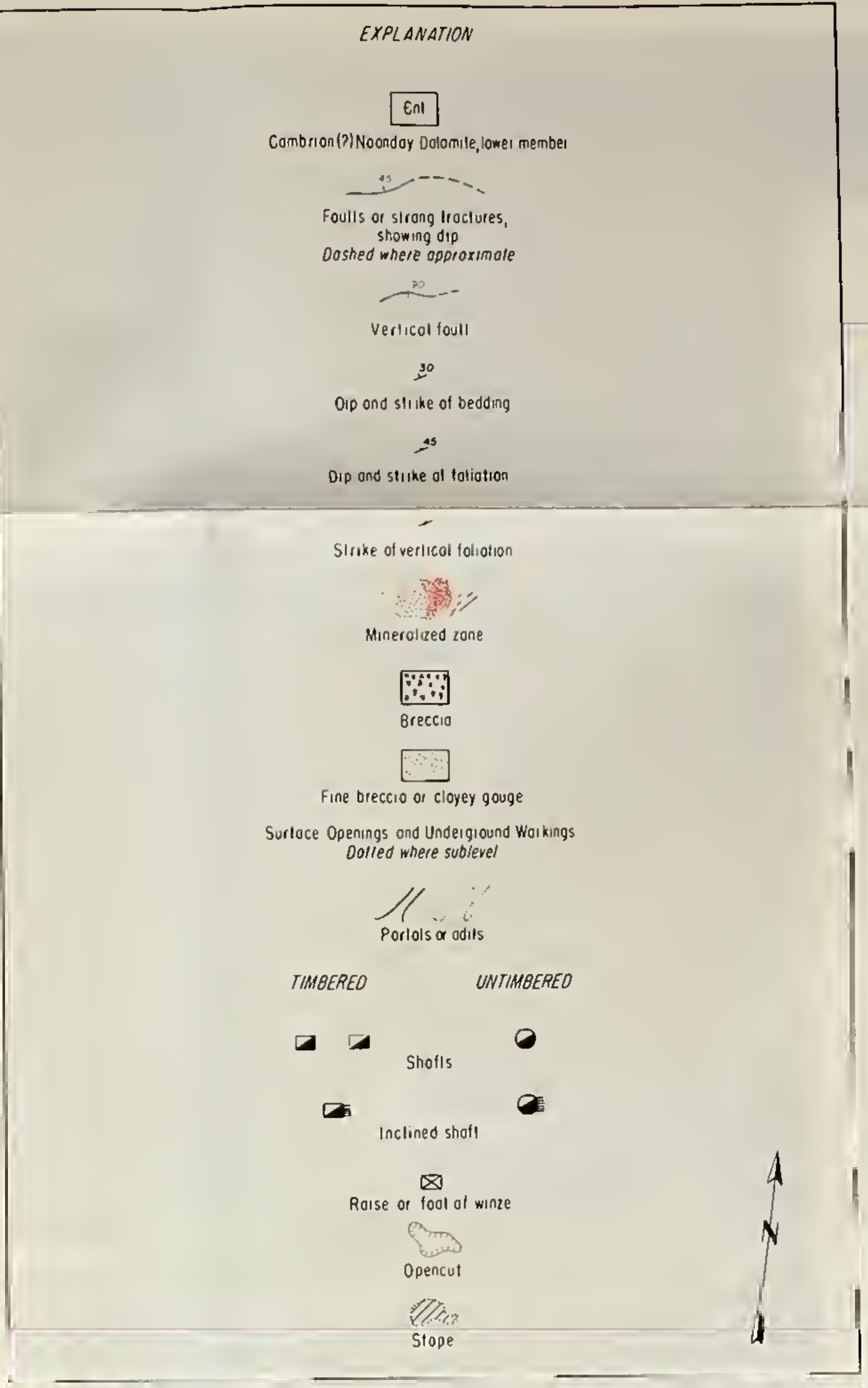
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION

SPECIAL REPORT 88
PLATE 3


Surface
Єnl
45
clayey gouge
CLAY FAULT ZONE
30
clayey gouge
Єnl
clayey gouge
45
40
Єnl
Єnl
45
SHEBA FAULT ZONE
little gouge in numerous fractures
Єnl
fine breccia
Єnl
coarse breccia
fine breccia
manganiferous coating fractures common
Єnl
severely brecciated
hematite and hydrous iron oxides
hematite and hydrous iron oxides
hematite and hydrous iron oxides
Єnl
pre-iron fault ?
hematite and hydrous iron oxides
weakly fractured zone
hematite and hydrous iron oxides
hematite and hydrous iron oxides

LOWER CROSSCUT (elevation 1157')*


EXPLANATION

Єnl
Cambrian (?) Noonday Dolomite, lower member

Faults or strong fractures, showing dip
Dashed where approximate

Vertical fault

Dip and strike of bedding

Dip and strike of foliation

Strike of vertical foliation

Mineralized zone

Breccia

Fine breccia or clayey gouge

Surface Openings and Underground Workings
Dotted where sublevel

Portals or adits

TIMBERED *UNTIMBERED*

Shafts

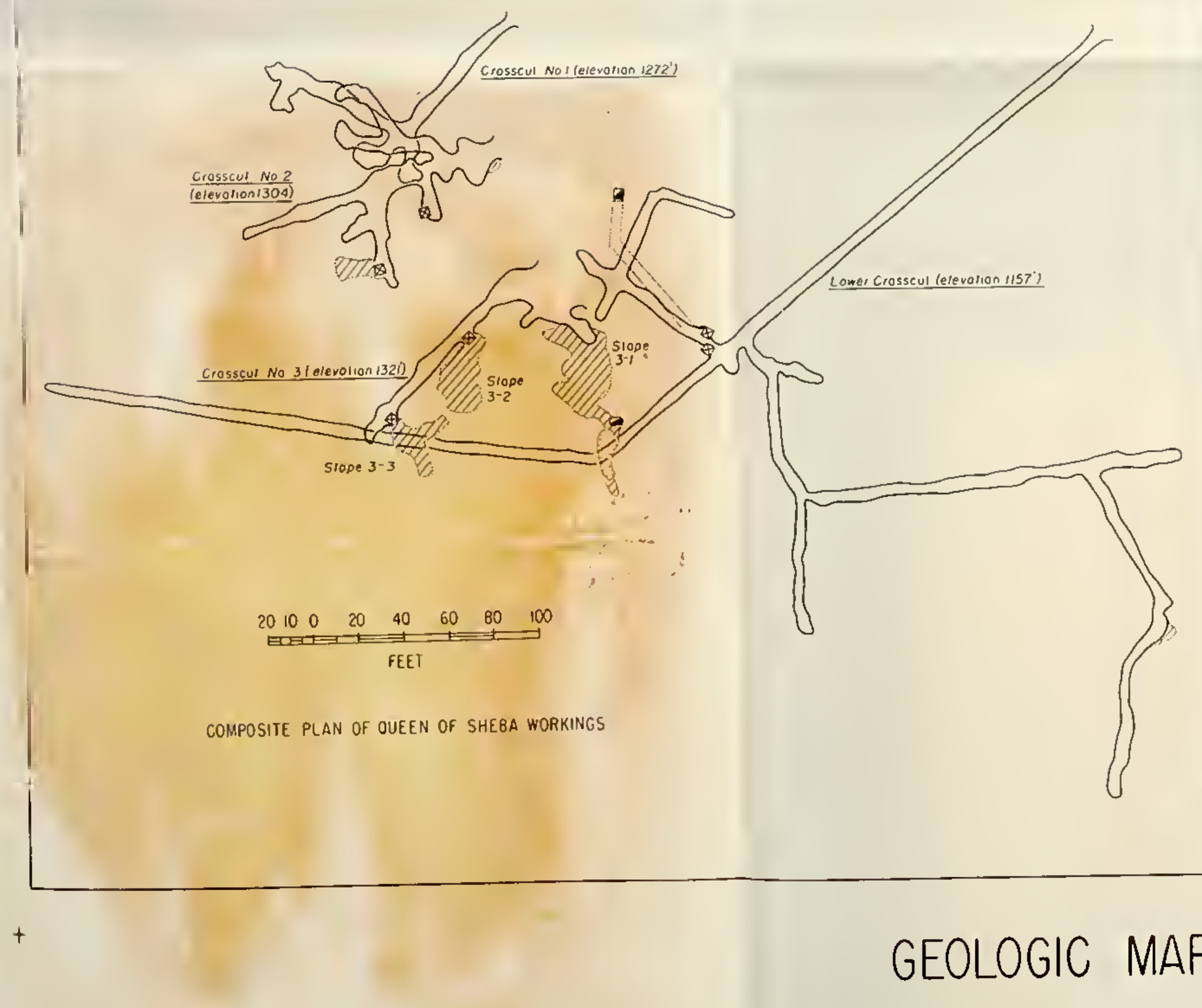
Inclined shaft

Raise or foot of winze

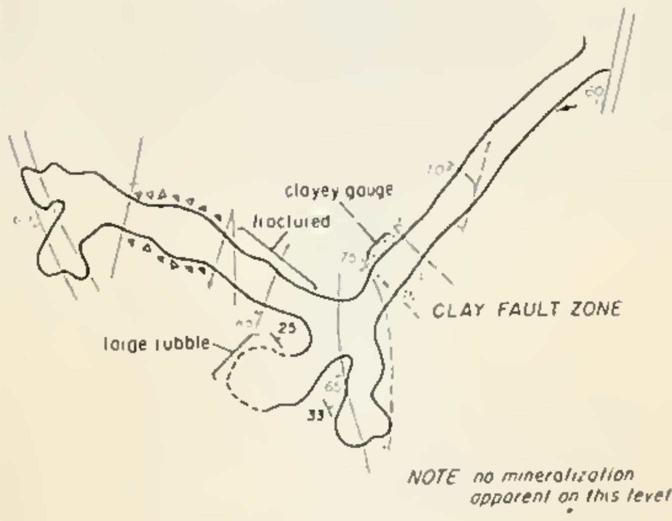
Opencut

Stope

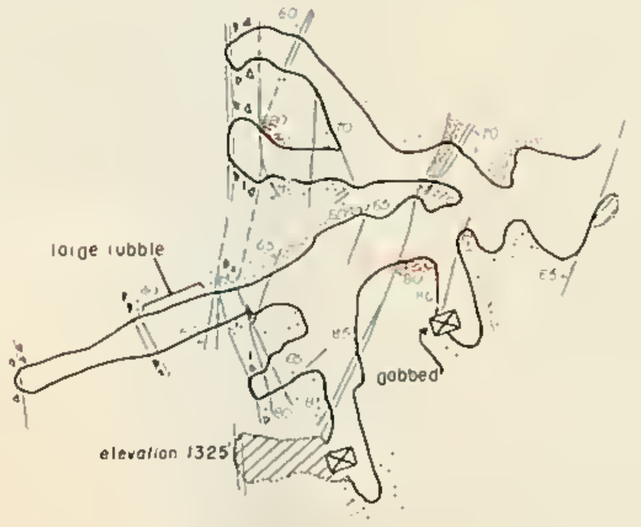
*NOTE All elevations noted in the geologic map titles are approximate


Crosscut No 1 (elevation 1272')
Crosscut No 2 (elevation 1304)
Lower Crosscut (elevation 1157')
Stope 3-1
Stope 3-2
Crosscut No 3 (elevation 1321)
Stope 3-3
20 10 0 20 40 60 80 100
FEET

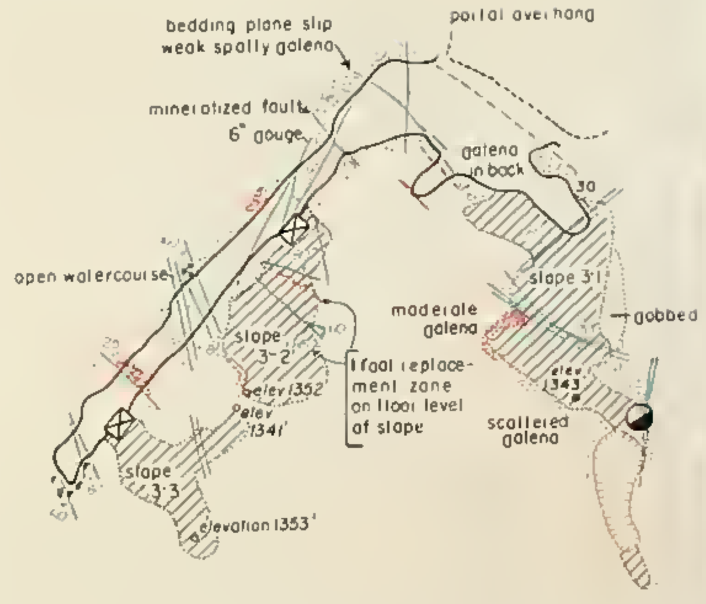
COMPOSITE PLAN OF QUEEN OF SHEBA WORKINGS



CROSSCUT NO. 1 (elevation 1272')*



CROSSCUT NO. 2*
(elevation 1304')



CROSSCUT NO. 3 (elevation 1321')*

GEOLOGIC MAPS OF THE QUEEN OF SHEBA WORKINGS

20 10 0 20 40 60 80 100
FEET